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(54) **Controlled cryogenic contact system**

Geregeltes Kontak-Tieftemperatur-Kühlsystem

Système contrôlé de réfrigération cryogénique en contact

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Description

Field of the Invention

[0001] The present invention relates to apparatus for carrying out operations involving cryogenic temperatures as well as temperatures above 0°C. More particularly, the invention is directed to apparatus which permits to carry out such operations in a highly controlled manner.

Background of the Invention

[0002] The ability to cause fast changes in temperatures, particularly between very low temperatures and room or higher temperatures, on a desired surface and at a desired location, is of practical importance in many uses. Fast temperature changes can be exploited, for instance, in the treatment of various materials, for sealing or surface curing purposes, etc.

[0003] Cold and hot surfaces are used also for medical uses. For instance, cryogenic techniques are employed to destroy malignant tissues, or for plastic surgery. One example of such a use is presented in SU 774,549, which relates to a thermal treatment of biological tissues by passing heat carriers through a cryosurgical probe. The method is said to be useful in the cryosurgery of the human brain. This method, however, involves passing a heat carrier through a surgical probe, its subsequent heating and repeated passage through the probe. Acetone or alcohol are used as the heat carrier. Prior to its passage through the probe the heat carrier is either cooled to -70-75°C, or heated to +70-90°C.

[0004] Devices of this type present severe drawbacks, inasmuch as they have long lags in temperature changes, they require cumbersome heating/cooling apparatus outside the probe, and are complicated and expensive to use.

[0005] Cryosurgical instruments having both cryocooling and heating capabilities are also known in the art. One such device and its medical use have been described by Andrew A. Gage ["Current Issues in Cryosurgery", *Cryobiology* **19**, 219-222(1982), at pp. 220-21]. The device described therein was cooled by liquid nitrogen and electrically heated, to provide hemostasis. The electrical heating, however, by its nature is a relatively slow procedure.

[0006] Another device is described in SU 1,217,377, which exploits the expansion of gases through an orifice. However, simple expansion of gas through an orifice provides relatively slow temperature changes, and the changes in temperature are relatively mild. Thus, for instance, in the device of SU 1,217,377 it is not possible to liquefy nitrogen. Additionally, this prior art device employs helium at room temperature which, expanding from a pressure of about 300 atmospheres, will attain a heating of merely about 30°C. In any case, in the single pass expansion described in this reference, liquefaction of nitrogen cannot be achieved. However, helium has an inversion temperature of about 45K, which renders it possible to employ neon or hydrogen as the second gas, as is done in this reference. The highest inversion temperature of neon is about 200K, and of hydrogen is about 180K. Accordingly, these gases cannot be used while using nitrogen as the first gas, because the temperature of liquid nitrogen is 80K, and thus the heating obtainable with neon and hydrogen is low. Additionally, neon and hydrogen may be found at an inversion temperature lower than their maximal temperature, so that no heating is obtained. However, neon is expensive and hydrogen is dangerous, and the obtainable temperatures are unsatisfactory for many uses, which accounts for the lack of success of the above-mentioned device.

[0007] FR-A-2 477 406 discloses a cryosurgical apparatus suitable to destroy diseased cells by means of freezing which comprises a probe having a contact surface, a jacket and an orifice opening into said jacket, a transfer line comprising two concentric tubes and a heat exchanger connected to the transfer line, the concentric tubes being constituted by a inner capillary tube for leading a cooling fluid under high pressure to said orifice and an outer tube for flowing out said fluid having a low pressure from the jacket once it is expanded through the orifice

[0008] FR-A-2 482 445 which constitutes an application for an additional patent to FR-A-2 477 406 relates to an improvement to the cryosurgical apparatus disclosed in FR-A-2 477 406, the improvement consisting of providing means to said apparatus for heating the contact surface of the probe. In particular, the heating of said contact surface can be obtained by expansion through an orifice of a gas such as helium or neon.

[0009] EP-A-0 608 927 filed on January 13, 1994, the specification of which is incorporated herein by reference, is a European patent application falling within the terms of Art. 54 (3) EPC.

[0010] This document discloses a method by means of which a fast and periodic change of surface temperature, even down to cryogenic range, can be created, at the desired location, in a simple and effective manner. This is achieved by creating a surface having a fast changing temperature, by providing a heat exchanger coupled to an orifice opening into a jacket which is in contact with the surface to be heated and cooled, the said jacket forming a reservoir capable of housing a fluid in contact with the surface to be heated and cooled, and providing two gas sources, each gas source being independently connected to the said heat exchanger, one source providing a first gas, which liquefies when it expands through the said orifice, and the other gas source providing a second gas, having an inversion temperature lower than the temperature obtained by the liquefaction of the first gas, and causing the exhaust gas flowing out from the said jacket, to flow through the said heat-exchanger to preheat or precool the inflowing gas, as the case may be, and further causing the said first

and the said second gas alternately to flow through the said heat exchanger and orifice, to cool or to heat the said surface; means being provided for allowing and stopping the flow of each gas through the said orifice.

[0011] The selection of appropriate gases is crucial. For instance, the maximum inversion temperature of helium is 43K. Thus, even when somewhat precooled by boiling nitrogen at 77.3K, it still will warm up when undergoing Joule-Thomson expansion. Furthermore, providing a preheating or precooling of the inflowing gas is not just a matter of efficiency or saving, but is an essential part of the invention, since processes and devices employing a one-pass heating or cooling, without utilizing an exchange of heat via an appropriate heat-exchanger, will not provide sufficiently low or sufficiently high temperatures, and will result in a temperature change which is excessively slow.

[0012] Heat exchangers can be of any type, and may be, e.g., a finned tube heat-exchanger of a porous-matrix heat-exchanger, e.g., of the type described in British Patent No. 1,422,445. The device described in this British patent provides only for the cryocooling of the probe, the purpose being to maintain the temperature of the probe below -80°C, thus avoiding altogether the need for heating the probe. It should be mentioned that, according to the teachings of this patent, heating was necessary, when operating at temperatures above -80°C, for the purpose to prevent the probe from sticking to the tissue. However, when operating according to EP 0 608 927 A with fast cooling-heating cycles, the heat exchanger can be utilized also for heating purposes.

[0013] The first gas is preferably selected from the group consisting essentially of argon, nitrogen, air, krypton, CF_4, xenon and N_2O, and the second gas is helium.

[0014] Cryogenic liquefaction occurs at the tip of the cold extremity of the device operating according to EP 0 608 927 A under the cooled metal surface. The Linde-Hampson method is applied, using the Joule-Thomson effect for cooldown to liquefaction.

[0015] EP 0 608 927 A also describes an apparatus for the cryocooling and the heating of surfaces, comprising:

1) a heat exchanger coupled to an orifice, the said orifice opening into a jacket;
2) a jacket which is in contact with the surface to be heated and cooled, the said jacket forming a reservoir capable of housing a fluid in contact with the surface to be heated and cooled;
3) two pressurized gas sources, each gas source being independently connected to the said heat exchanger;
4) means for allowing and stopping the flow of each gas through the said orifice.

[0016] The method of EP 0 608 927 A makes it possible to obtain a high frequency of temperature change. Thus, for instance, one may which, for a given application, to oscillate between temperatures of -50°C and +100°C only.

SUMMARY OF THE INVENTION

[0017] It has now been found, and this is an object of the present invention, that it is highly advantageous to be able to control the operation of the heating/cooling device the temperature of which changes rapidly, for a variety of uses and applications.

[0018] It is an object of the present invention to provide an apparatus which permits to control the temperature obtained on the contact surface of a probe in which heating and cooling is achieved by the Joule-Thomson effect obtained through the expansion of gases.

[0019] It is another object of the invention to provide an apparatus which can be easily operated by unskilled operators while providing highly precise and controlled temperatures.

[0020] It is still another object of the invention to provide an apparatus which can be pre-programmed to create desired temperature changes with time in an appropriate probe.

[0021] It is still a further object of the invention to provide a relatively inexpensive, easy to use and convenient to operate apparatus of the type described above. Other objects of the invention will become apparent as the description proceeds.

[0022] The apparatus for creating controlled temperature changes on a contact surface, according to the invention, comprises:

a) a probe having a contact surface, a jacket and heat exchanging means coupled to an orifice and involving a tube from which the orifice opens into said jacket;
b) a first reservoir for a first gas under pressure which produces cooling when expanding through said orifice by Joule-Thomson effect and a second reservoir for a second gas under pressure which produces heating when expanding through said orifice by reverse Joule-Thomson effect;
c) two lines for leading said gases to said probe;
d) valve means for causing said first and second gas to flow to the probe;

characterized in that it further comprises processing means which control said valve means according to a predetermined program to alternate the supply of said two gases to the jacket in predetermined operating conditions.

[0023] The probe can be any suitable probe, of any type and shape, which utilizes the Joule-Thomson effect. For example, the probe described in EP 0 608 927 A can be suitably used for this purpose.

[0024] According to a preferred embodiment of the invention, the apparatus comprises external data input means, to provide operation data to the processing

means, such as a keyboard, a communication port, e. g., RS232, or magnetic or optical reading means, to read pre-prepared data.

[0025] The apparatus may further comprise display means to display data written to, or read from, the processing means. The processing means can be of any suitable type, e.g., the apparatus may be coupled to a microcomputer programmed to carry out the functions described herein, as well as any other desired auxiliary function.

[0026] According to a preferred embodiment of the invention, the apparatus further comprises temperature-reading means located at or near the contact surface, which temperature-reading means provide temperature readings to the processing means. Such temperature-reading means may comprise, e.g., one or more thermocouples, but at least two thermocouples are preferred, to ensure continued feedback temperature readings. The temperature readings permit the processing means to determine whether the temperature is to be increased or decreased, in order to remain at the predetermined temperature, and to close or open the appropriate valves.

[0027] A further advantage of the apparatus of the invention is that it permits to alert the operator, when using pressurized gas reservoirs, of the remaining lifetime of the gas reservoir. In order to do so, in a preferred embodiment of the invention there are provided pressure-reading means located between the pressurized gas source and the probe, to provide to the processing means readings corresponding to pressure supplied by each pressurized gas source. Thus, during the emptying of a gas reservoir, its pressure decreases and the processing means, which keeps track of such pressures, can calculate the expected operation time remaining with the reservoir, on the basis of pressure changes with time in the specific operation undertaken.

[0028] The invention is also directed to a method of creating controlled temperature changes on a contact surface which comprises the steps of:

- providing an apparatus comprising:

  a) a probe having a contact surface, a jacket and heat exchanging means coupled to an orifice and involving a tube from which the orifice opens into said jacket;
  b) a first reservoir for a first gas under pressure which produces cooling when expanding through said orifice by Joule-Thomson effect and a second reservoir for a second gas under pressure which produces heating when expanding through said orifice by reverse Joule-Thomson effect;
  c) two lines for leading said gases to said probe;
  d) valve means for causing said first and second gas to flow to the probe ;

  the method being characterised in that said valve means are controlled by processing means to alternate the supply of said two gases to the jacket according to predetermined operating conditions programmed in said processing means.

[0029] According to a preferred embodiment of the method said predetermined operating conditions comprise alternating periodically the supply of said two gases

[0030] All the above and other characteristics and advantages of the invention will be better understood through the following illustrative and non-limitative description of preferred embodiment.

Brief Description of The Drawings

[0031] In the drawings:

Fig. 1 is a schematic perspective view of an apparatus according to one preferred embodiment of the invention;
Fig. 2 schematically shows of a probe, according to one preferred embodiment of the invention, shown in partial cross-section;
Fig. 3 schematically illustrates the controlled operation of the apparatus of Fig. 1;
Fig. 4 shows controlled temperature readings taken at the contact surface of the probe of Fig. 2, coupled to the apparatus of Figs. 1 and 3, in the experiment described in Example 1;
Fig. 5 shows controlled temperature readings taken under the contact surface of a speciment, in the experiment described in Example 2.

Detailed Description of Preferred Embodiments

[0032] Fig. 1 illustrates a device according to a preferred embodiment of the invention. This device is designed to be movable and self-supporting, and does not require connection to outside gas sources. It consists of a body 1, provided with wheels 2, which houses two gas reservoirs (not shown). The reservoirs can be replaced through the backdoor, which is not seen in the figure. An additional door 3 gives access to the inside of the body, and is used for parts replacement and maintenance, as well as for housing spare parts.

[0033] A probe 4 is connected to the gas reservoirs and to a microprocessor, as explained above and in further detail below, through line 5. All connections are within body 1. A keyboard 6 and a display 7 are provided on the front panel of the apparatus, along with on-off switch 8 control lights 8' and 8", which can be used to indicate the operation status of the apparatus, e.g., to indicate at any given time whether it is cooling or heating.

[0034] Since the electric power requirements of the apparatus are relatively very low, the apparatus is pow-

ered by a DC source, such as a battery, but may alternatively be connected to an AC source.

[0035] Fig. 2 shows the probe 4 of Fig. 1 in greater detail. The Joule-Thomson heat exchanger 9 serves contact surface 10, which is heated or cooled, depending on the nature of the gas flowing therethrough. Thermocouple 11 is in close contact with the inner part of contact surface 10, and detects the temperature at that location. The thermocouple wire is led to the processing means through line 5 and connector 12. The gas leaving the probe is exhausted to the atmosphere either through connections in the probe, or at connector 12.

[0036] The probe is provided with a main switch 13, operating switches 14, 15 and 16, and monitor lights 14', 15' and 16'. These switches operate the probe towards cooling or heating, or for preset cooling/heating cycles, and the lights indicate the operation being performed. Manual operation or microprocessor-controlled operation can be chosen.

[0037] Looking now at Fig. 3, a central processing unit (CPU) controls the operation of the apparatus, according to predetermined operating conditions provided to it. Programming of the operating conditions can be made through keyboard 6 of Fig. 1 (indicated by KB in the figure), or through a communication port CP, connected to a programming computer, or through a data reader DR, e.g., a magnetic or optical reader. The data can be displayed on a display, e.g., a liquid crystal display (LCD), and the keyboard can be used also to read data from the CPU and to display them on the LCD. The CPU can be provided with a substantial memory, so as to store not only operating parameters to be controlled, but also data received during the operation, e.g., temperature or pressure readings.

[0038] Data contained in the memory of the CPU can be printed out, e.g., through an RS232 or similar port.

[0039] Line 5 of probe 4 contains two incoming gas lines, 17 and 18, as well as an outgoing thermocouple line 19, the readings of which are fed to the CPU. In response, and in order to maintain the preprogrammed temperature in the probe contact surface, the CPU operates the two controllable valves 20 and 21, which control the flow of gas into the probe 4. Two pressure gauges, 22 and 23, provide pressure readings to the CPU, which relate to the pressure in reservoirs 24 and 25.

Example 1

[0040] An apparatus was built according to the embodiment described above. It included E-type thermocouples, a 18 mm diameter probe, with a length of 160 mm. The gases employed were argon (for cooling) and helium (for heating). The diameter of the contact surface of the probe was 6 mm.

[0041] In order to test the controllability of the apparatus, the temperatures range was set around a single temperature at a given time, and three different temperatures were tested. these were -140°C, -120°C and -80°C. Each temperature was maintained for 5 minutes, as seen in Fig. 4 which shows the thermocouple readings (11 in Fig. 2) for this experiment. It can be seen that the apparatus of the invention is capable of maintaining a virtually constant temperature, by alternating two different gases with a high frequency.

Example 2

[0042] The apparatus of Example 1 was used in an experiment in which it was desired periodically to cool a surface to cryogenic temperature (-165°C) and then to above-zero temperature (44°C), the frequency of oscillation between the two extreme temperatures being required to be 38 seconds. These data were fed to the CPU, which was preprogrammed accordingly. The details of the computer program are not given herein for the sake of brevity, since providing an appropriate program is within the scope of the routineer.

[0043] The specimen on the surface of which the probe was applied was a potato. The resulting temperature readings at the contact surface are shown in Fig. 5. Additional temperature readings were taken within the potato, at a depth of 2 mm below its surface, directly below the contact surface of the probe. The resulting temperature cycles within the potato are also depicted in Fig. 5 (smaller wave), and it can be seen that the minimal temperature reached at a depth of 2 mm is about -50°C, using a probe temperature of -165°C. The highest temperature at the same depth was about 0°C. As indicated on the figure, about 35% of the 38 seconds cycle was devoted to cooling, and 65% to heating.

Claims

1. Apparatus for producing controlled temperature changes on a contact surface (10) comprising:

   a) a probe (4) having a contact surface (10), a jacket and heat exchanging means (9) coupled to an orifice and involving a tube from which the orifice opens into said jacket;
   b) a first reservoir (24) for a first gas under pressure which produces cooling when expanding through said orifice by Joule-Thomson effect and a second reservoir (25) for a second gas under pressure which produces heating when expanding through said orifice by reverse Joule-Thomson effect;
   c) two lines (17, 18) for leading said gases to said probe (4);
   d) valve means (20,21) for causing said first and second gas to flow to the probe (4);

   characterized in that it further comprises processing means which control said valve means (20,21) according to a predetermined program to alternate

the supply of said two gases to the jacket in predetermined operating conditions.

2. Apparatus according to Claim 1, wherein said processing means comprise microprocessor means.

3. Apparatus according to Claim 1 or 2, further comprising data input means, to provide operation data to the processing means.

4. Apparatus according to Claim 3, wherein the data input means comprise a keyboard (6).

5. Apparatus according to Claim 4, further comprising display means (7) to display data written to, or read from, the processing means.

6. Apparatus according to Claim 3, wherein the data input means comprise a communication port.

7. Apparatus according to Claim 6, wherein the communication port is an RS232 port.

8. Apparatus according to Claim 3, wherein the data input means comprise magnetical or optical reading means, to read pre-prepared data.

9. Apparatus according to anyone of Claims 1 to 8, further comprising temperature-reading means located at or near the contact surface (10), which temperature-reading means provide temperature-readings to the processing means.

10. Apparatus according to Claim 9, wherein the temperature-reading means comprise one or more thermocouples (11).

11. Apparatus according to anyone of Claims 1 to 10, further comprising pressure-reading means (22,23) located between the pressurized gas reservoirs (24, 25) and the probe (4), to provide to the processing means readings corresponding to pressure supplied bye each pressurized gas reservoir (24, 25).

12. A method for creating controlled temperature changes on a contact surface (10) which comprises the steps of:

- providing an apparatus comprising:

  a) a probe (4) having a contact surface (10), a jacket and heat exchanging means (9) coupled to an orifice and involving a tube from which the orifice opens into said jacket;
  b) a first reservoir (24) for a first gas under pressure which produces cooling when expanding through said orifice by Joule-Thomson effect and a second reservoir (25) for a second gas under pressure which produces heating when expanding through said orifice by reverse Joule-Thomson effect;
  c) two lines (17, 18) for leading said gases to said probe (4);
  d) valve means (20,21) for causing said first and second gas to flow to the probe (4);

  the method being **characterised in that** said valve means (20,21) are controlled by processing means to alternate the supply of said two gases to the jacket according to predetermined operating conditions programmed in said processing means.

13. A method according to claim 12 wherein said predetermined operating conditions comprise alternating periodically the supply of said two gases.

Patentansprüche

1. Vorrichtung zum Erzeugen gesteuerter Temperaturänderungen auf einer Kontaktoberfläche (10) mit:

   a) einer Sonde (4), die eine Kontaktoberfläche (10), eine Mantel- und Wärmeaustauscheinrichtung (9), die mit einer Öffnung gekoppelt ist und ein Rohr miteinbezieht, von dem sich die Öffnung in den Mantel öffnet, umfaßt;
   b) einem ersten Reservoir (24) für ein erstes, unter Druck stehendes Gas, das Kühlung beim Ausdehnen durch die Öffnung durch den Joule-Thomson-Effekt erzeugt, und einem zweiten Reservoir (25) für ein zweites, unter Druck stehendes Gas, das Wärme beim Ausdehnen durch die Öffnung durch den umgekehrten Joule-Thomson-Effekt erzeugt;
   c) zwei Leitungen (17,18) zum Führen der Gase zu der Sonde (4);
   d) Ventileinrichtungen (20,21) zum Veranlassen, daß das erste und zweite Gas zu der Sonde (4) fließt;

   dadurch gekennzeichnet, daß sie ferner Verarbeitungsmittel umfaßt, die die Ventileinrichtungen (20,21) gemäß einem vorbestimmten Programm steuern, um die Zufuhr der beiden Gase an den Mantel bei vorbestimmten Betriebsbedingungen abzuwechseln.

2. Vorrichtung gemäß Anspruch 1, bei der die Verarbeitungsmittel Mikroprozessormittel umfassen.

3. Vorrichtung gemäß Anspruch 1 oder 2, ferner mit Dateneingabemittel, um Betriebsdaten an die Verarbeitungsmittel zu liefern.

4. Vorrichtung gemäß Anspruch 3, bei der die Dateneingabemittel eine Tastatur (6) umfassen.

5. Vorrichtung gemäß Anspruch 4, ferner mit Anzeigemittel (7), um in die Verarbeitungsmittel geschriebenen oder von diesen gelesenen Daten anzuzeigen.

6. Vorrichtung gemäß Anspruch 3, bei der die Dateneingabemittel einen Kommunikationsport umfassen.

7. Vorrichtung gemäß Anspruch 6, bei der das Kommunikationsport ein RS232-Port ist.

8. Vorrichtung gemäß Anspruch 3, bei der die Dateneingabemittel magnetische oder optische Lesemittel umfassen, um vorbereitete Daten zu lesen.

9. Vorrichtung gemäß einem der Ansprüche 1 bis 8, ferner mit Temperaturlesemittel, die sich an oder nahe der Kontaktoberfläche (10) befinden, wobei die Temperaturlesemittel Temperaturablesungen an die Verarbeitungsmittel liefern.

10. Vorrichtung gemäß Anspruch 9, bei der die Temperaturlesemittel ein oder mehrere Thermoelemente (11) umfassen.

11. Vorrichtung gemäß einem der Ansprüche 1 bis 10, ferner mit zwischen den unter Druck stehenden Reservoirs (24,25) und der Sonde (4) befindlichen Druckablesemittel (22,23), um an die Verarbeitungsmittel Ablesungen zu liefern, die dem Druck entsprechen, der von jedem unter Druck stehenden Gasreservoir (24,25) geliefert wird.

12. Verfahren zum Erzeugen gesteuerter Temperaturänderungen auf einer Kontaktoberfläche (10), mit folgenden Schritten:

- Bereitstellen einer Vorrichtung mit:

  a) einer Sonde (4), die eine Kontaktoberfläche (10), eine Mantel- und Wärmeaustauscheinrichtung (9), die mit einer Öffnung gekoppelt ist und ein Rohr miteinbezieht, von dem sich die Öffnung in den Mantel öffnet, umfaßt;
  b) einem ersten Reservoir (24) für ein erstes, unter Druck stehendes Gas, das Kühlung beim Ausdehnen durch die Öffnung durch den Joule-Thomson-Effekt erzeugt, und einem zweiten Reservoir (25) für ein zweites, unter Druck stehendes Gas, das Wärme beim Ausdehnen durch die Öffnung durch den umgekehrten Joule-Thomson-Effekt erzeugt;
  c) zwei Leitungen (17,18) zum Führen der Gase zu der Sonde (4);
  d) Ventileinrichtungen (20,21) zum Veranlassen, daß das erste und zweite Gas zu der Sonde (4) fließt;

wobei das Verfahren **dadurch gekennzeichnet** ist, daß die Ventileinrichtungen (20,21) durch Verarbeitungsmittel gesteuert werden, um die Zufuhr der beiden Gase an den Mantel gemäß vorbestimmten, in den Verarbeitungsmitteln programmierten Betriebsbedingungen abzuwechseln.

13. Verfahren gemäß Anspruch 12, bei dem die vorbestimmten Betriebsbedingungen ein periodisch Abwechseln der Zufuhr der beiden Gase umfaßt.

Revendications

1. Appareil pour produire des changements de température maîtrisés sur une surface de contact (10) comprenant :

   a) une sonde (4) ayant une surface de contact (10), une enveloppe et des moyens d'échange de chaleur (9) couplés à un orifice et impliquant un tube d'où l'orifice s'ouvre à l'intérieur de ladite enveloppe ;
   b) un premier réservoir (24) pour un premier gaz sous pression qui produit un refroidissement quand il se détend à travers ledit orifice par effet Joule-Thomson et un second réservoir (25) pour un second gaz sous pression qui produit un échauffement quand il se détend à travers ledit orifice par effet Joule-Thomson inverse ;
   c) deux canalisations (17, 18) pour conduire lesdits gaz vers ladite sonde (4) ;
   d) des moyens de vanne (20, 21) pour obliger lesdits premier et second gaz à s'écouler vers la sonde (4) ;

   caractérisé en ce qu'il comprend de plus des moyens de traitement qui commandent lesdits moyens de vanne (20, 21) selon un programme prédéterminé pour alterner l'alimentation desdits deux gaz vers l'enveloppe dans des conditions de fonctionnement prédéterminées.

2. Appareil selon la revendication 1, dans lequel lesdits moyens de traitement comprennent des moyens de microprocesseur.

3. Appareil selon la revendication 1 ou 2, comprenant de plus des moyens d'entrée de données pour fournir des données de fonctionnement aux moyens de traitement.

4. Appareil selon la revendication 3, dans lequel les moyens d'entrée de données comprennent un clavier (6).

5. Appareil selon la revendication 4, comprenant de plus des moyens d'affichage (7) pour afficher les données écrites vers, ou lues provenant des moyens de traitement.

6. Appareil selon la revendication 3, dans lequel les moyens d'entrée de données comprennent un port de communication.

7. Appareil selon la revendication 6, dans lequel le port de communication est un port RS232.

8. Appareil selon la revendication 3, dans lequel les moyens d'entrée de données comprennent des moyens de lecture magnétique ou optique, pour lire des données pré-préparées.

9. Appareil selon l'une quelconque des revendications 1 à 8, comprenant de plus des moyens de lecture température situés au niveau ou proche de la surface de contact (10), moyens de lecture de température qui fournissent des lectures de température aux moyens de traitement.

10. Appareil selon la revendication 9, dans lequel les moyens de lecture de température comprennent un ou plusieurs thermocouples (11).

11. Appareil selon l'une quelconque des revendications 1 à 10, comprenant de plus des moyens de lecture de pression (22, 23) situés entre les réservoirs de gaz sous pression (24, 25) et la sonde (4), pour fournir aux moyens de traitement des lectures correspondant à la pression fournie par chacun des réservoir de gaz sous pression (24, 25).

12. Procédé pour créer des changements de température maîtrisés sur une surface de contact (10) qui comprend les étapes consistant :

- à fournir un appareil comprenant :

  a) une sonde (4) ayant une surface de contact (10), une enveloppe et des moyens d'échange de chaleur (9) couplés à un orifice et impliquant un tube d'où l'orifice s'ouvre dans ladite enveloppe ;
  b) un premier réservoir (24) pour un premier gaz sous pression qui produit un refroidissement quand il se détend à travers ledit orifice par effet Joule-Thomson et un second réservoir (25) pour un second gaz sous pression qui produit un échauffement quand il se détend à travers ledit orifice par effet Joule-Thomson inverse ;
  c) deux canalisations (17, 18) pour conduire lesdits gaz à ladite sonde (4) ;
  d) des moyens de vanne (20, 21) pour obliger lesdits premier et second gaz à s'écouler vers la sonde (4) ;

le procédé étant **caractérisé en ce que** lesdits moyens de vanne (20, 21) sont commandés par des moyens de traitement pour alterner la fourniture desdits deux gaz à l'enveloppe selon des conditions de fonctionnement prédéterminées programmées dans lesdits moyens de traitement.

13. Procédé selon la revendication 12, dans lequel lesdites conditions de fonctionnement prédéterminées comprennent l'étape consistant à alterner périodiquement la fourniture desdits cieux gaz.

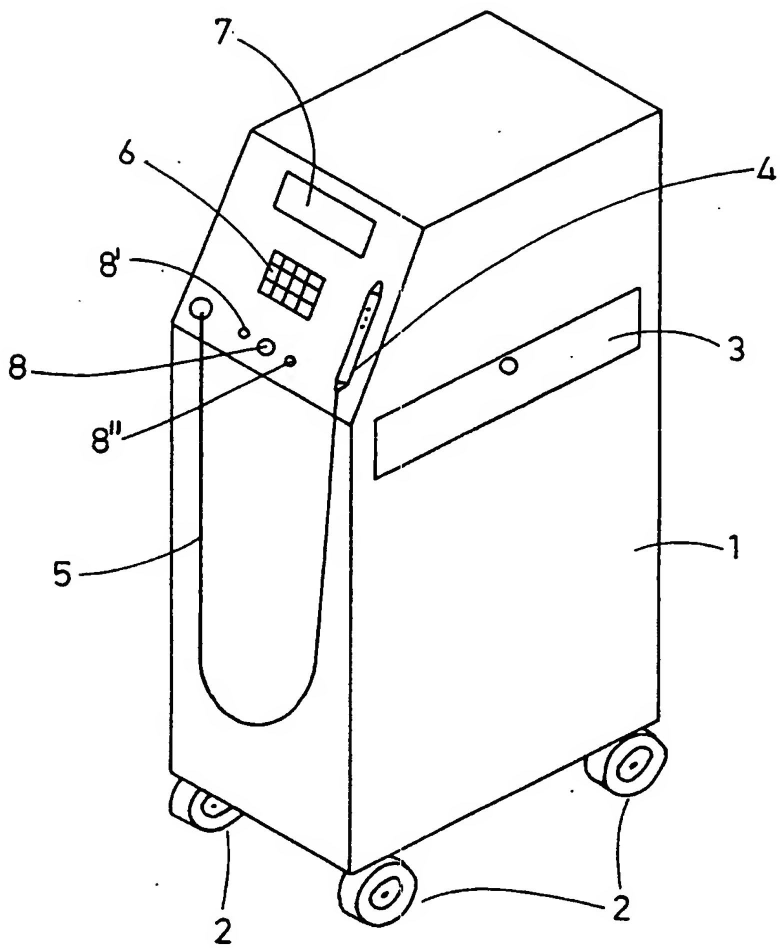

Fig. 1

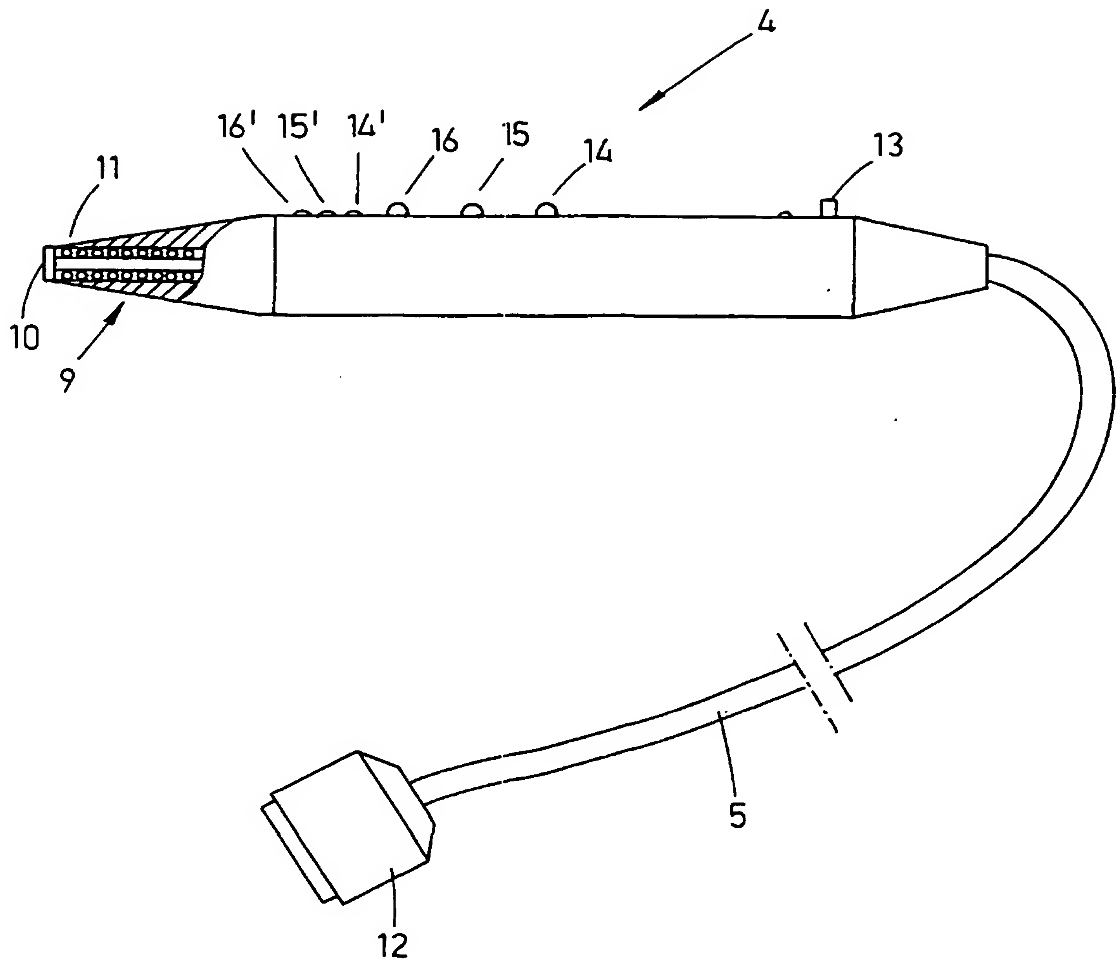

Fig. 2

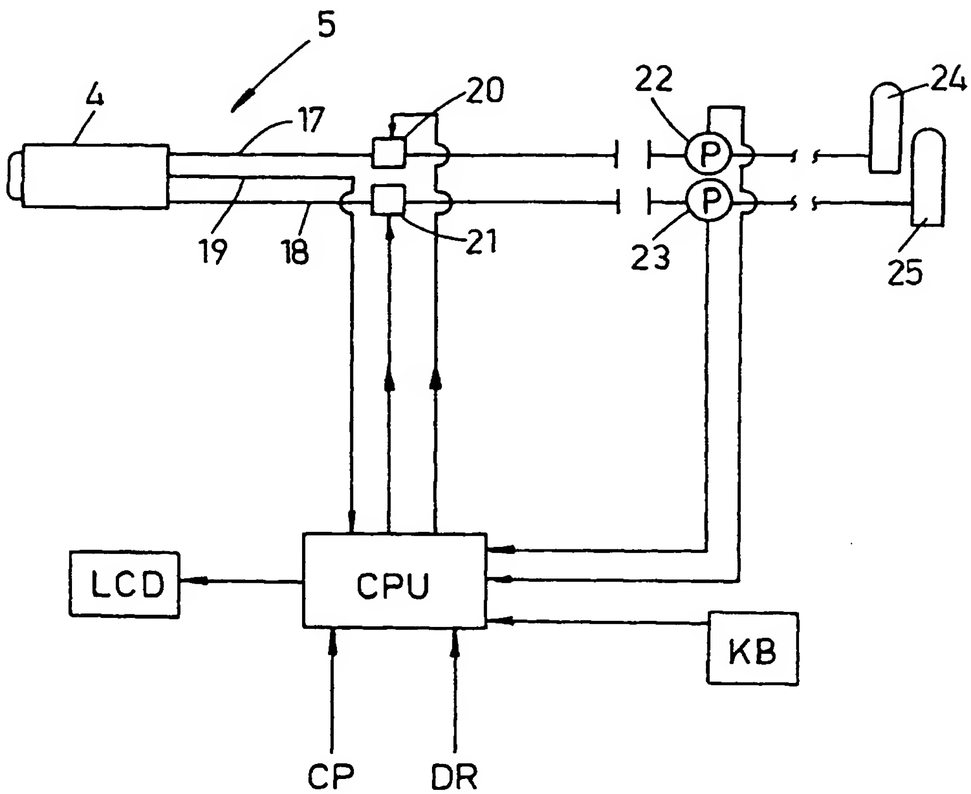

Fig. 3

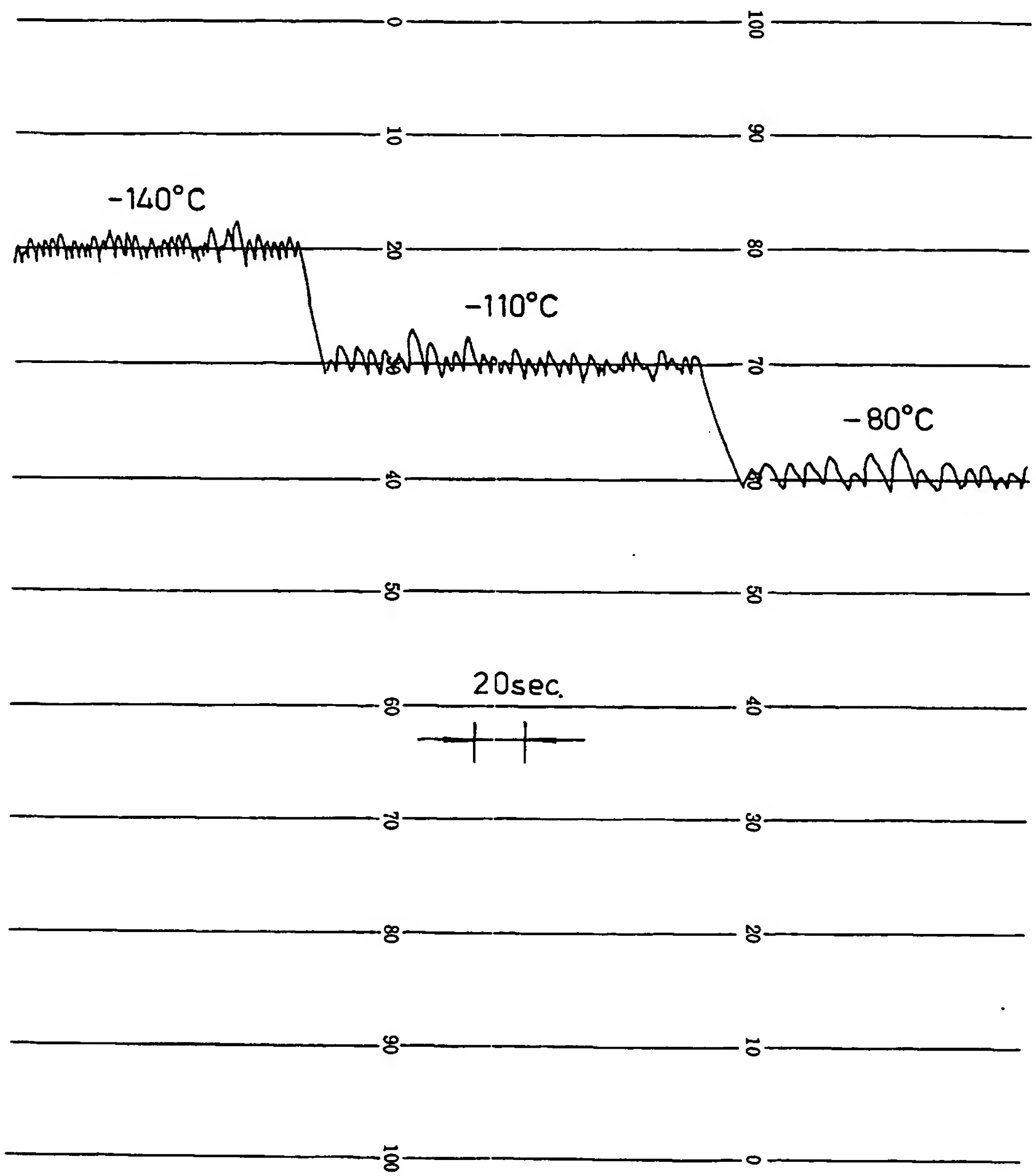

Fig. 4

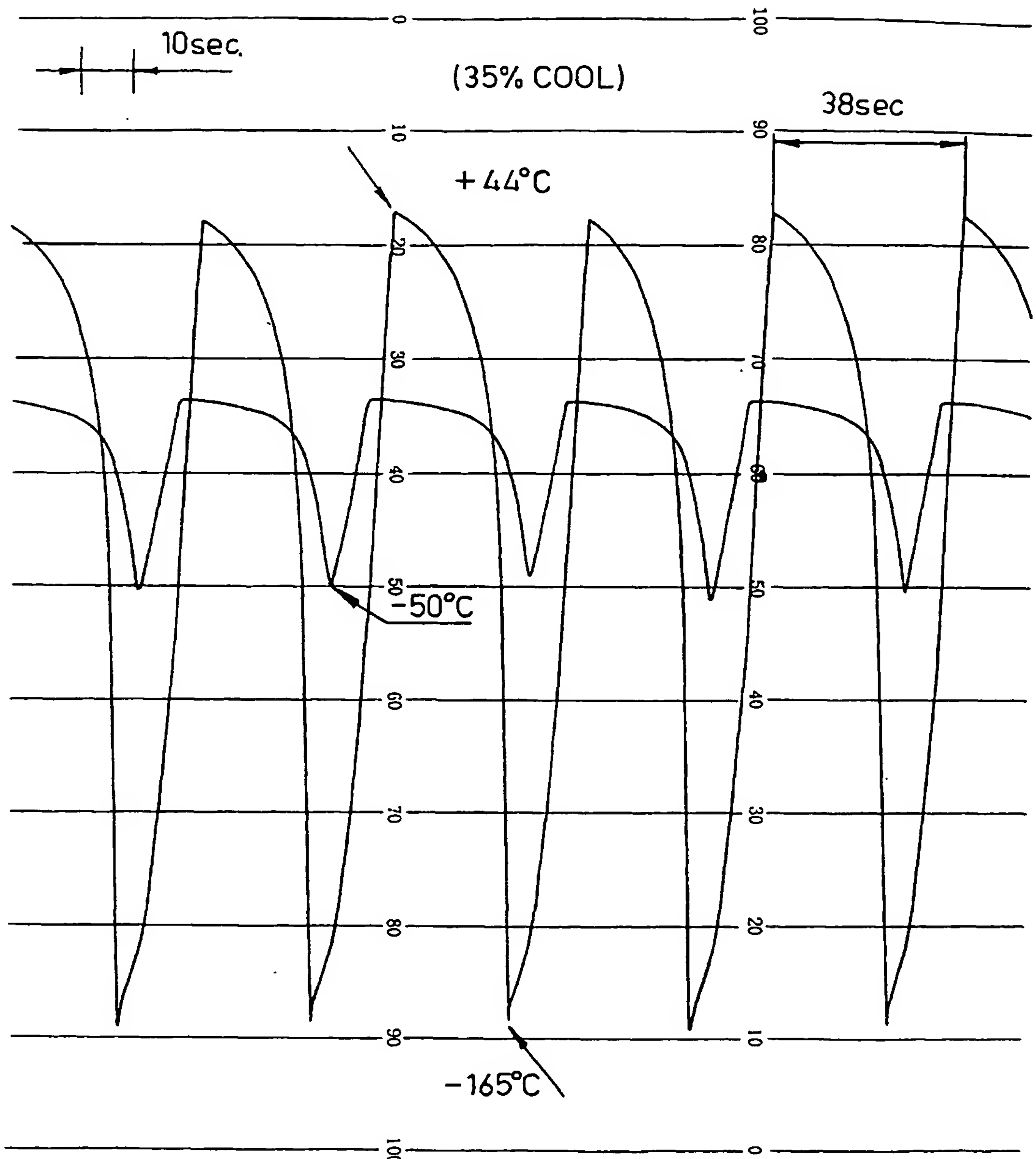
10sec.
(35% COOL)
38sec
+44°C
-50°C
-165°C
0
10
20
30
40
50
60
70
80
90
100
100
90
80
70
60
50
40
30
20
10
0

Fig. 5